Transportation Research Part D 62 (2018) 152–168

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

The impact of air-railways transportation, energy demand, bilateral aid flows, and population density on environmental degradation: Evidence from a panel of next-11 countries

Hummera Saleem[a], Wen Jiandong[a], Khalid Zaman[b,*], Elsayed Elsherbini Elashkar[c], Alaa Mohamd Shoukry[c,d]

[a] Department of Economics, Wuhan University, Wuhan, China
[b] Department of Economics, University of Wah, Quaid Avenue, Wah Cantt, Pakistan
[c] Arriyadh Community College, King Saud University, Riyadh, Saudi Arabia
[d] KSA Workers University, El Mansoura, Egypt

ARTICLE INFO

Keywords:
Air-railways transportation
Energy demand
Bilateral aid flows
Population density
Environmental degradation
Next-11 countries

ABSTRACT

Transportation considers the highly volatile sector that deteriorates the environment with carbon dioxide (CO_2) and greenhouse gas (GHG) emissions. Such emissions are not only responsible for climate change, but also escalate the natural resource rents that are mediated with national scale economic indicators to diffuse the sustainability agenda across the globe. This study mainly focused on air-railways transportation, energy demand, bilateral aid flows, population density and environmental degradation in a panel of Next-11 countries, for the period of 1975–2015. The results confirmed the existence of environmental Kuznets curve (EKC) for air-railways passengers carried and per capita income with CO_2 emissions, while there is a U-shaped relationship between railways passengers carried and GHG emissions. The monotonic increasing relationship of air transport passengers carried and bilateral aid flow is established with the natural resource rents. Railways goods transported, energy demand, and population density escalates CO_2 emissions, while energy demand and population density further increase GHG emissions. The air transport freight has a positive relationship with the GHG emissions and negative relationship with the natural resource rents in a panel of countries. The causality estimates confirmed the bidirectional relationship of environmental factors and railways transportation with the per capita income, while there is a unidirectional causality running from energy to bilateral aid and growth. The results of variance decomposition analysis show that air transport passengers carried, energy demand, and bilateral aid is the key predictor that will largely influence CO_2 emissions, GHG emissions, and natural resource rents, for the next ten year period.

1. Introduction

The economic and environmental impacts of transport sector is crucial for broad-based economic growth, as it is chiefly attributed with unsustainable growth paths, as we are consuming global energy is nearly about 20% and around one-forth energy induced carbon emissions that is projected to likely increase 50% by 2030 and additionally incremented 30% expected in 2030 makes its around 80% by 2050. This impact is obviously alarmed for future sustainable policies, which indicates the vulnerable impact on

* Corresponding author.
E-mail address: Khalid_zaman786@yahoo.com (K. Zaman).

https://doi.org/10.1016/j.trd.2018.02.016

Available online 28 February 2018
1361-9209/ © 2018 Elsevier Ltd. All rights reserved.

natural environment in a form of climate change and global rise in GHG emissions (IEA, 2009).

In 2005 Goldman Sachs mooted the BRIC successors, known as the Next-11 countries, which comprises the set of different countries including developed country (South Korea), newly industrialized countries (Indonesia, Iran, Mexico, the Philippines, and Turkey), and developing countries (Bangladesh, Egypt, Nigeria, Pakistan, and Vietnam). The Next-11 countries enjoyed a large growing population base which enhanced its consumer market and attract the domestic and foreign firms to invest in the economy by reaping economic profits (Eghbal, 2008). Transport associated carbon emissions is one of the mounting concern in the Next-11 countries, which is seriously threaten the climate change and global warming situation that need to be addressed as per the concerns of Intergovernmental Panel on Climate Change (IPCC, 2014), which indicated the overwhelming increase of direct transport carbon emissions by 2050 if aggressive and sustained policy interventions not been made in the global environmental agenda. The improvement in air quality indicators is the desirable solution to reduce the threat of climate change impact on economic growth, while it is further need to search the desirable renewable energy sources that less sensitized with the carbon emissions. The Next-11 countries should follow the path of energy conservation and cleaner production techniques to improve global environment (Shahbaz et al., 2016).

There are number of sources that overwhelming increase transport associated carbon emissions and their resulting impact on global climate change and GHG emissions i.e., (i) the growth of private vehicles that considerably affect the oil demand and its prices, which further leads to GHG emissions (Yan and Crookes, 2009); (ii) highway fuel consumption, crude oil and petroleum products, conventional sources of energy intensive fossil fuel consumption, and purchase tax credits for new vehicle purchase, all leads to GHG emissions (Morrow et al., 2010); (iii) rapid economic growth and vehicle ownership considerably increase CO_2 emissions (Lu et al., 2007); (iv) truck freight intensification of CO_2 emissions (Kamakate and Schipper, 2009); (v) logistics activities based emissions including freight demand and truck fuel consumption (Piecyk and McKinnon, 2010); (vi) freight transport operations increases high tons carbon emissions (McKinnon, 2007); (vii) road transportation consumed gasoline and diesel more faster than any other sector that largely linked with GHG emissions (Ong et al., 2012), etc. These are the main predictors that affect largely environmental sustainability agenda by transport emissions across the globe.

He et al. (2005) pointed out that oil consumption increases due to road transportation demand in China while it is imperative to proposed sound policy measures to improve motor vehicle design that will give large oil saving benefits to the country. Ramachandra (2009) concluded the fact that trade liberalization and government policies considerably increases the road vehicles in different states of India, which considered the potential determinants of GHG emissions, while the crucial fact is that Maharashtra's state largely contribute to 11.8% of road vehicle emissions, followed by Tamil Nadu about 10.8%, Gujarat about 9.6%, Uttar Pradesh about 7.1%, Rajasthan about 6.22% and, Karnataka is about to 6.19%. These statistics firmly indicates the road transport emissions which is the serious concern of India's energy and environmental reforms, which required sound policy vista for sustainable transportation agenda at countrywide. Timilsina and Shrestha (2009) identified different national scale indicators that affect the transport associated carbon emissions in the selected Asian countries and found that, in general, rapid changes in economic growth, population, and energy intensified transportation sector are the main predictor that influences transportation emissions. The study proposed number of policy measures to reduce transportation sector emissions including tax structure, government expenditures and subsidy programmes, renewable energy sources, less carbon intensified fuel consumption, etc. These measures would helpful to reduce the threat to climate change and global warming, which further for promoting sustainable transportation across the globe. Liaquat et al. (2010) presented the importance of biofuels consumption as a means of using transportation fuel, which is less sensitive to the carbon emissions; while it is easier for its production for developing countries that have strong agricultural setups from energy crops. On the other way around, higher growth in the urban population and strive hard to progression in economic growth of developing countries, the carbon mitigating policies are not an easy task for their policy planners. It is suggested that the road transportation emissions substantially may reduce by adopting biofuels production in biofuel operated automotives in this region. Lin (2010) emphasized the need of public transport use that set it out for reaching to the tourists destinations and it would helpful to reduce energy demand and transport associated carbon emissions. Mao et al. (2012) proposed different policy options to reduce transport sector CO_2 emissions including fuel tax and energy taxes, however, it is necessary to set the tax rates that helpful to achieve this mitigation target at nationwide.

Geng et al. (2013) concluded with some possible solution to the gradual phase-out of inefficient vehicles i.e., purchase of green vehicles, infrastructure improvement and capacity-building initiatives. Uusitalo et al. (2013) emphasized the need of efficient energy use that helpful to reduce GHG emissions from the transport sector. The renewable energy sources played a pivotal role to reduce GHG emissions that resulted into minimize the threat of climate change. The study recommended for the use of biogas in the electric cars and/or gas operated cars for transport sustainability. Chandran and Tang (2013) investigated the long-run relationship between transportation induced energy demand and carbon emissions in selected ASEAN countries and found a positive impact of transport energy and economic growth on CO_2 emissions, which leads to the conclusion of transport sustainability that is possible only to independent with the use of fossil fuel energy and use of energy efficient transportation technologies for improving natural environmental quality. Abdallah et al. (2013) investigated the non-linear relationship between transport emissions and transportation growth in Tunisia and found an inverse N-shaped relationship between them. This result does not establish the inverted U-shaped relationship; therefore, it is suggested to device sound policy framework for transportation sustainability in the better interest of economic and environmental agenda. Saboori et al. (2014) examined the relationship between road transportation induced energy, economic growth and carbon emissions in a panel of OECD countries and found a feedback relationship between them. In addition, the impulse response function shows differential policy shocks in terms of larger and relatively shorter responses between the variables for the next ten year period. The study concluded with the fact that road transportation energy consumption should be shifted to the renewable energy sources including power energy and biofuel consumption to mitigate global GHG emissions.

Xu and Lin (2015) selected a provincial Chinese panel data for the period of 2000 to 2012 to examine the non-linear effects of economic growth on transport carbon emissions and found an inverted U-shaped EKC hypothesis for economic growth, urbanization, private vehicle populations cargo turnover, while it follows a U-shaped relationship with the energy efficiency in a region. These carbon driven factors need sustainable policy instruments for reducing the threat of GHG emissions by efficient transportation mode. Walmsley et al. (2015) presented four–point policy agenda to likely reduce transport emissions i.e., rail transportation should all be electrified, energy efficiency and up gradation in the transportation technologies, plug–in hybrid vehicle technologies, and biomass energy consumption. These policies will greatly impact on transport emissions by less consumption of fossil fuel energy and largely impact on renewable base energy source for sustainable transportation. Li et al. (2016) found that transport carbon emissions highly at risk by emerging trend in commercial centers in Chinese cities, however, the types and locations of commercial centers have diversified portfolio to increase transport led carbon emissions, as commercial centers in the periphery of Shenyang, province of China emitted road transportation carbon per trip around 6.94% that are higher than urban core city and 26.92% higher than in the inner city. The wholesale centers have a greater share in order to increase road emissions by more than three times from the inner city centers. Thus the policy should require for an effective road energy transportation usage in a commercial centers for mitigating carbon emissions in a country. Zhao et al. (2016) found some significant players that inhibit the progression of transport induced energy and carbon emissions including the tertiary industry structure in China that substantially reduced the overwhelming increase of transport emissions while this carbon emissions reduction till no more sustained if it is not properly controlled the rapid growth of population and per capita growth. The country needs an effective policy blend of environmental sustainability instruments to control carbon emissions. Talbi (2017) investigated the impact of fuel energy consumption, road transportation energy, fuel rate and urbanization on air quality indicators in Tunisia and found a significant and positive impact of fuel rate and fuel energy consumption on reduction in CO_2 emissions which further translated into EKC relationship between economic development and carbon emissions in a country. The policy to sustained economic activity is supported by national scale indicators that facilitate to reduce carbon emissions at countrywide. Langbroek et al. (2017) concluded that electric vehicles are the promising solution to reduce environmental damages and decreases substantial amount of GHG emissions, especially by generating the electricity with renewable energy sources, however, it remains restrained due to general perceptions of the consumer about electric vehicles, including higher electric costs and lower cost of operations. The results emphasized the need of green vehicles for sustainable transportation. López-Martínez et al. (2017) proposed an integrated methodology to estimate air emissions and fuel consumption by urban bus fleet in the Madrid city. The results estimated the fuel consumption and air pollution by different buses at different routes in the given city and provided such empirical estimates about the emergence of air pollutants and intervention measures to regulate policies for sustainable transportation. Waycaster et al. (forthcoming) discussed the safety and regulatory mechanism of the U.S. transportation system that is considered highly responsible for providing safety standards to their peoples regarding prevention from accidental fatalities in a given country. In addition, the funds have been generated to the transportation sector for maintaining the road safety and regulatory mechanism for reducing any uncertainty in the form of aviation and road fatalities. The results of the study compared the safety standards and new regulations during the period of 2002–2009 and conclude that government regulations for maintaining safety standards by commercial aviations and bus transportation exert the largest amount of spending as compared to the general aviations and private vehicles, which is highly unlikely in terms of received less regulatory attention to the private transportation. The study emphasized the need of thorough investigation in terms of remedial measures to observe the effectiveness level by different modes of transportation in a country. Mansfield and Gibson (2017) designed micro-simulation model to estimate the combined health impacts by different modes of transportation and found that health impacts are substantial lower in the most walkable block groups as compared to the least walkable block groups by transportation, while particulate matter (PM2.5) have a greater health risks in the region. The other two effects of transportation sector, including crash risks and physical inactivity both are lower in the walkable block groups. The study concludes that active transportation has a significant health benefits and thus suggested healthy policies for safe transportation system across countries.

The above significant discussions comes to the following conclusions i.e.,

- **Negative impacts:**
  - (i) Transportation sector profoundly increase carbon emissions and energy demand.
  - (ii) Road transportation has a major share in order to increase carbon emissions and energy demand.
  - (iii) Higher economic growth and rapid population affects transport emissions.
  - (iv) Transport induced energy demand deteriorates air quality indicators.
  - (v) Investment, aid, and trade further increase the power of transportation that affects the natural environment, etc.
- **Positive impacts:**
  - (i) Sustainable transportation is the key to mitigate carbon emissions and GHG emissions.
  - (ii) Energy and transport fuel taxes improved the quality of air indicators.
  - (iii) Biomass, biofuel, and other renewable energy sources are less sensitive to the transport emissions.
  - (iv) Green investment in transportation sector is desirable for long-term sustainable policy.
  - (v) Urban planning for transportation management is required for less carbon emissions, etc.

1.1. Literature gap(s) and contribution of the study

The previous studies largely worked on travel and transport services (see, Paulley et al., 2006, Thøgersen, 2009, Olsson et al., 2012, Nassani et al., 2017, etc.), logistics performance indices (see, Lai and Wong, 2012, Zaman and Shamsuddin, 2017, Khan et al.,

2017a, etc.), tourism transportation expenditures (see, Zaman et al., 2017, Khan et al., 2017b, Qureshi et al., 2017, etc.), truck freight (see, Konur, 2014, Kim and Van Wee, 2014, Sim, 2017, etc.), truck fuel consumption (see, Wu et al., 2015, Walnum and Simonsen, 2015, etc.), road safety, aviation and road fatalities (see, Waycaster et al., forthcoming), etc. These stated studies worked under different economic and environmental factors in different economic settings, however, to date, a very limited number of the studies directly confined the role of air-railways transportation on carbon-GHG emissions that gives one of the motivations to do work under this unfilled gap through mediating energy demand, bilateral aid flows, and population density, which confirmed the number of alternative and plausible hypothesis, including, EKC hypothesis, energy associated emissions, population based emissions, and aid led emissions hypothesis in a panel of NEXT 11 countries. The real contribution of the study is to combined different environmental sustainability criteria under one roof by investigating aviation based emissions, railways transport emissions, and channelizing different economic factors together to reduce climatic externalities and achieve sustainability criteria for long-term growth. The selection of panel econometric techniques was another challenge to give robust inferences under the given scenario; hence, the study employed a series of econometric cointegration techniques to give reliable parameter estimates. The causality estimates and panel forecasting further gives new insights about the variable's relationships in a given countries contexts, which previously were ignored in the past literatures.

1.2. Objectives of the study

The objective of the study is to examine the impact of air transportation, railways transportation, economic growth, energy demand, and population density on carbon emissions, GHG emissions, and natural resource rents in a panel of NEXT-11 countries. The more specific objectives are:

(i) To examine an inverted U-shaped EKC hypothesis for air transportation, railways transportation, economic growth, and bilateral aid flows with respect to CO_2 emissions, GHG emissions, and natural resource rents.
(ii) To examine the causal relationships between air-railways transportation, economic growth, energy demand, bilateral aid, population density, and environmental factors, and
(iii) To assess the policy shocks response to transportation, national scale indicators, and environmental factors for the next ten year period.

These objectives achieved by panel econometric techniques for robust inferences in a panel of Next-11 countries.

2. Data source and methodological framework

The study used different national scale economic indicators to examine their impact on environmental degradation in a panel of Next-11 countries, for the period of 1975–2015. The air transportation comprises air transportation freight in million ton-km (denoted by AIRTF) and air transportation passengers carried (denoted by AIRTPC), while railways transportation comprises goods transported by railways in million ton-km (denoted by RAILGT) and passengers carried by railways in million passenger-km denoted by RAILPC). The environmental factors consider CO_2 emissions in metric tons per capita (denoted by CO_2), greenhouse gas emissions (denoted by GHG) in kiloton of carbon equivalent, and Total natural resources rents as% of GDP (denoted by NATRENT). The other variables are energy demand in kg of oil equivalent per capita (denoted by ENRG), per capita income in constant 2010 US$ (denoted by GDPPC), net bilateral aid flows from Development Assistance Committee donors in current US$ (denoted by AID), and population density in people per sq. km of land area (denoted by POPDEN). The data comes from World Development Indicator (WDI) published by World Bank (2015). The subsequent and/or preceding values are used to filled the data gaps of the respective variables, where required. Fig. 1 shows the plots of level data for ready reference.

The study consulting the various recent literature on the transportation and environmental degradation that intermediate with the national scale economic indicators and found an inverted U-shaped Kuznets curve for flex-fuel vehicles (Almeida et al., 2016), for energy-environment efficiency in the railway sectors and followed the U-shaped curves for road sectors (Liu et al., 2016), while emphasize on low carbon urban transport (Mittal et al., 2016) and sustainable tourism transportation expenditures (Zaman et al., 2017) required more policy intervention to realize the decoupling carbon emissions and transportation research across nations (Wang et al., 2017). It is evident that global sustainability agenda more prone to the social, economic, and environmental performance which is affected by transport sector (Loo and Banister, 2016) while air and railways transportation consider the significant predictor to advance international mobility (Khan et al., 2017b) on the cost of air pollution (Jebli, 2016). Following the above studies, this study added air transportation, railways transportation, energy demand, per capita income, bilateral aid flows, and population density in the emissions modeling through environmental Kuznets curve (EKC) framework and formulated the three broad models with number of subsequent equations i.e.,

Model-1: Linkages between air-railways transportation, energy demand, bilateral aid flows, population density and CO_2 emissions

$$\ln(CO_2)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(AIRTPC)^2_{it} + \psi_4 \ln(RAILGT)_{it} + \psi_5 \ln(RAILPC)_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (1)$$

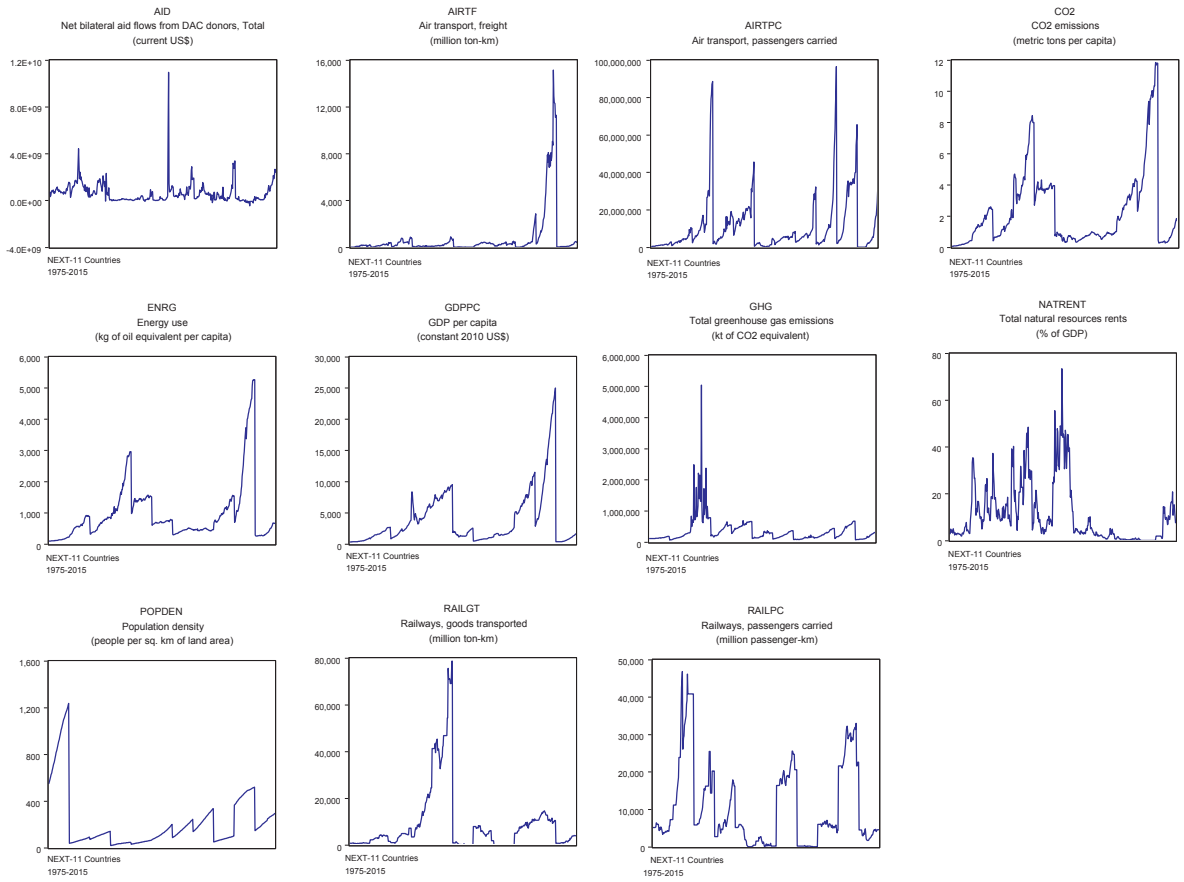


Fig. 1. Plots of level data.
Source: World Bank (2015).

$$\ln(CO_2)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(RAILPC)^2_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (2)$$

$$\ln(CO_2)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(GDPPC)^2_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (3)$$

$$\ln(CO_2)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(AID)_{it} + \psi_8 \ln(AID)^2_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (4)$$

Model-11: Linkages between air-railways transportation, energy demand, bilateral aid flows, population density and GHG emissions

$$\ln(GHG)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(AIRTPC)^2_{it} + \psi_4 \ln(RAILGT)_{it} + \psi_5 \ln(RAILPC)_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (5)$$

$$\ln(GHG)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(RAILPC)^2_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (6)$$

$$\ln(GHG)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(GDPPC)^2_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (7)$$

$$\ln(GHG)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(AID)_{it} + \psi_8 \ln(AID)^2_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (8)$$

Model-111: Linkages between air-railways transportation, energy demand, bilateral aid flows, population density and Total Natural Resources Rents

$$\ln(NATRENT)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(AIRTPC)^2_{it} + \psi_4 \ln(RAILGT)_{it} + \psi_5 \ln(RAILPC)_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (9)$$

$$\ln(NATRENT)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(RAILPC)^2_{it} + \psi_6 \ln(ENRG)_{it} + \psi_7 \ln(GDPPC)_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (10)$$

$$\ln(NATRENT)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(GDPPC)^2_{it} + \psi_8 \ln(AID)_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (11)$$

$$\ln(NATRENT)_{it} = \psi_0 + \psi_1 \ln(AIRTF)_{it} + \psi_2 \ln(AIRTPC)_{it} + \psi_3 \ln(RAILGT)_{it} + \psi_4 \ln(RAILPC)_{it} + \psi_5 \ln(ENRG)_{it} + \psi_6 \ln(GDPPC)_{it} + \psi_7 \ln(AID)_{it} + \psi_8 \ln(AID)^2_{it} + \psi_9 \ln(POPDEN)_{it} + \varepsilon_{it} \quad (12)$$

where CO_2 indicates carbon emissions, GHG indicates greenhouse gas emissions, NATRENT indicates natural resources rents, AIRTF indicates air transport freight, AIRTPC indicates air transport passengers carried, RAILGT indicates railways goods transported, RAILPC indicates railways passengers carried, ENRG indicates energy demand, GDPPC indicates per capita GDP, AID Indicates bilateral aid flows, POPDEN indicates population density, 'i' indicates Next-11 countries, 't'; indicates 1975–2015 time period, 'ln' indicates natural logarithm, and ε indicates error term.

The impact of air-railways transportation freight and passengers carried are expected to have a positive relationship with the carbon emissions, GHG emissions, and total natural resources rents, as transportation sector highly sensitive with the air pollutants and natural resources that considerably affected the sustainable transportation agenda across nations. In addition, the results are expected to have a negative coefficient values of the square term of air-railways passengers carried, per capita GDP, and bilateral aid flows to confirmed the inverted U-shaped Kuznets curve in relation with the carbon emissions, GHG emissions and total natural resources rents. The positive relationship is expected in between the energy demand and environmental degradation in the form of increasing carbon emissions, GHG emissions, and natural resources rents. The impact of per capita income and its square term is expected to have a positive and negative impact on environmental degradation respectively, which would support the EKC hypothesis. The bilateral aid flows and its square term expected to have a positive and negative impact on carbon emissions, GHG emissions, and total natural resources rents respectively, which would support an inverted U-shaped relationship between them. Finally, the impact on population density on environmental degradation is expected to have a positive relationship with the environmental degradation, as intensification of population growth on arable land deteriorates the environment in a form of high carbon and GHG emissions, while it further escalates the natural resources rents in a region.

The study employed heterogeneous panel cointegration techniques to evaluate the potential impact of transportation modes, energy demand, economic growth, aid, and population density on CO_2 emissions, GHG emissions, and natural resources rents across Next-11 countries. The panel unit root tests are employed to check the stationary series of the candidate variables by four methods, namely, Levin, Line, and Chu (LLC, 2002) test, Im, Pesaran, and Shin (IPS, 2003) test, Fisher–ADF chi-square test, and Fisher–PP chi-square test. The significant statistics values of these prescribed tests reject the null hypothesis of common unit root process in LLC panel unit root test, and further reject the null hypothesis of individual unit root process in IPS panel unit root, Fisher–ADF and Fisher-PP panel unit root tests. The estimates of panel unit root tests confirmed the order of integration for the selected variables, as the rejection of null hypothesis confirmed that the variables are differenced stationary and have an order of integration is one i.e., I (1), while acceptance of null hypothesis assumes the common and/or individual unit root process shows that the selected variable are level stationary and have an order of integration is zero i.e., I(0). The importance of I(1) and I(0) variables in the panel setting have a considerable significance in order to decide the appropriate heterogeneous panel econometric techniques, as having all variables are differenced stationary, the panel cointegration technique is highly acceptable while having a mix order of integration between the variables may further proceed for pooled mean group (or Autoregressive Distributed Lag Models).

The cross-sectional dependence tests are now in stylist fashion in cross-sectional-time series model that have a null hypothesis of no cross-sectional dependence, which is rejected by the significant statistic values of Breusch-Pagan Lagrange Multiplier (LM_{BP}), Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran Cross-sectional Dependence (CD) tests. The failure to reject the null hypothesis will confirm that the selected variables have no correlation with the cross-sections that further proceed towards the panel fixed effect and/or panel random effect models. On the other hand, the rejection of null hypothesis implies that the selected variables have cross-sectional dependence that required dynamic panel econometric techniques for robust inferences. For this purpose, before applied the dynamic panel estimators, the panel cointegration techniques should be used for cointegration relationships between the selected variables. The study used Fisher panel cointegration test and evaluate the 'no cointegration' hypothesis against the 'cointegration' hypothesis by trace test and maximum-Eigen test. The significant statistics of trace test and maximum-Eigen test reject the 'no cointegration' hypothesis and accept the alternative ones, which provoked the need of dynamic OLS estimator for robust inferences.

By addressing the long-run equilibrium relationships between the variables by Fisher panel cointegration test, the study used panel Fully Modified OLS (FMOLS) cointegrating regression as proposed by Pedroni (1996). The previous literature largely filled by applying panel fixed effect model (see, Wang et al., 2016, Al-Mulali et al., 2015, Zoundi, 2017, Zhang et al., 2017, etc.), however, this

technique has a serious limitations under the cross-sectional dependence that unable to explain the heterogeneity and cross-sectional dependence across countries, which caused serious forecasting errors (see, Dogan and Aslan, 2017). The FMOLS and DOLS estimator is the appropriate choice for parameter estimates while handling the cross-sectional dependency across countries, which further followed the Dumitrescu–Hurlin causality tests for analyzing the causation channels between the variables (see, Dogan et al., 2017, Shahbaz et al., 2015, Paramati et al., 2017, etc.). This technique further allows an efficient and consistent estimation of cointegration vector, which deals the simultaneity biases problem from the model. Hence, on the basis of significant importance of FMOLS estimator in panel estimations, we employed this technique for robust inferences. We precede this methodology to estimate Eqs. (1)–(12) equation for dealing heterogeneous cointegrated panels. FMOLS Pedroni's estimator is as follow:

$$\hat{\beta}_{FM} \quad \beta = \left(\sum_{i=1}^{N} \hat{\Omega}_{22i}^{2} \sum_{t=1}^{T} (x_{it} \quad \hat{x}_t)^2 \right)^1 \sum_{i=1}^{N} \hat{\Omega}_{11i}^{1} \hat{\Omega}_{22i}^{1} \left(\sum_{t=1}^{T} (x_{it} \quad \bar{x}_t) e_{it} \quad T\hat{\gamma}_i \right) \tag{13}$$

$$\hat{e}_{it}^{=} e_{it} \hat{\Omega}_{22i}^{1} \hat{\Omega}_{21i}, \quad \hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} \hat{\Omega}_{22i}^{1} \hat{\Omega}_{21i} \quad (\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0})$$

where $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i$, Ω_i^0 is the covariance matrix of that period, and Γ_i is a weighted addition of auto-covariances.

In the presence of cross-sectional dependence, Granger non-causality tests outperform in heterogeneous panels (Dumitrescu and Hurlin, 2012). The causality tests works under the null hypothesis i.e., the cross-sectional units are homogenous and have no causal relationships with them, while on the contrary side, the cross-sectional units have a causal relationships between the two sub-groups. The study used Dumitrescu-Hurlin causality tests which are based upon Wald statistics and Zbar statistics. The significance of both the statistics reject the null hypothesis of no causality in any of the cross-sectional units in a panel setting while reverse is true in case of insignificant statistics values. Finally, the study applied variance decomposition analysis in order to examine the inter-temporal relationships between transportation and environmental degradation with some intermediating factors, over the next ten years time periods i.e., from 2016 to 2025. This technique forecast the most influencing and least influencing factors that will affect the environment and natural resources for the next coming decade.

3. Results

This section presented the following statistical estimates i.e., descriptive statistics and correlation matrix is presented in Table 1. Table 2 shows the summary of panel unit root tests, Table 3 presented the cross-sectional dependence test, Table 4 shows the Fisher panel cointegration test, Table 5–7 presented the panel FMOLS estimates for different air pollutants, Table 8 shows the non-Granger homogenous panel causality estimates, and Table 9 presented the panel variance decomposition analysis.

Table 1, Panel–A shows the descriptive statistics of the selected variables, as the mean value of bilateral aid flows is about 6.38E +08 US$ with high kurtosis value. The air transport freight and railways goods transported have a mean value of 714.161 million ton-km and 8812.637 million ton-km respectively. The maximum value of air transport passengers carried and the railways passengers carried is about 96,604,665 in numbers and 46,851 million passengers–km with a mean value of 10,513,452 in numbers and 10519.100 million passengers–km respectively. The average value of CO_2 emissions, GHG emissions, natural resources rents, and energy demand is about 2.302 metric tons per capita, 345368.300 kt of carbon equivalent, 10.924% of GDP, and 961.358 kg of oil

Table 1
Descriptive statistics and correlation matrix.

Panel-A	AID	AIRTF	AIRTPC	CO_2	ENRG	GDPPC	GHG	NATRENT	POPDEN	RAILGT	RAILPC
Mean	6.38E+08	714.161	10,513,452	2.302	961.358	3836.123	345368.300	10.924	221.420	8812.637	10519.100
Maximum	1.10E+10	15162.610	96,604,665	11.840	5269.031	25022.800	5,040,841	73.488	1236.811	78,770	46,851
Minimum	−4.60E+08	0.013	6000	0.068	94.418	327.371	64845.900	0.013	20.098	0.695	67
Std. Dev.	8.84E+08	2000.970	14,687,202	2.486	957.533	4381.289	392174.100	12.648	255.315	14218.320	11046.370
Skewness	4.857	4.501	2.972	1.828	2.526	2.268	5.605	1.659	2.200	2.781	1.247
Kurtosis	47.332	23.957	13.613	6.209	9.958	9.147	53.811	5.525	7.554	10.953	3.718
Panel–B: Correlation Matrix											
AID	1										
AIRTF	−0.141	1									
AIRTPC	0.031	0.518	1								
CO_2	−0.273	0.736	0.537	1							
ENRG	−0.256	0.828	0.550	0.971	1						
GDPPC	−0.233	0.808	0.620	0.904	0.917	1					
GHG	0.061	0.164	0.345	0.210	0.230	0.212	1				
NATRENT	0.036	−0.247	−0.201	−0.042	−0.024	−0.202	0.048	1			
POPDEN	0.047	0.243	−0.046	−0.060	−0.025	−0.024	−0.157	−0.333	1		
RAILGT	−0.199	0.067	0.322	0.429	0.369	0.465	0.205	−0.067	−0.247	1	
RAILPC	0.087	0.390	0.179	0.353	0.339	0.224	0.113	−0.145	−0.001	−0.081	1

Note: AID indicates aid flows, AIRTF indicates air transport freight, AIRTPC indicates air transport passengers carried, CO_2 indicates carbon dioxide emissions, ENRG indicates energy demand, GDPPC indicates GDP per capita, GHG indicates greenhouse gas emissions, NATRENT indicates natural resources rents, POPDEN indicates population density, RAILGT indicates railways goods transported, and RAILPC indicates railways passengers carried.

Table 2
Panel unit root summary.

Methods	AID	AIRTF	AIRTPC	CO_2	ENRG	GDPPC	GHG	NATRENT	POPDEN	RAILGT	RAILPCC
LLC	0.786	1.714	11.385	0.597	0.489	6.600	1.350	−1.027	−1.749**	0.580	−0.629
IPS	0.041	1.349	10.244	2.276	2.829	8.104	3.546	−1.916**	2.622	2.396	0.697
Fisher-ADF	28.423	14.522	2.223	17.193	17.684	13.419	16.520	29.736	34.170**	10.853	13.286
Fisher-PP	40.414*	24.283	2.173	19.332	18.708	3.418	24.382	43.393*	46.862*	10.360	11.396
Methods	ΔAID	ΔAIRTF	ΔAIRTPC	ΔCO_2	ΔENRG	ΔGDPPC	ΔGHG	ΔNATRENT	ΔPOPDEN	ΔRAILGT	ΔRAILPC
LLC	−15.272*	−2.757*	−2.141**	−7.642*	−7.209*	−1.897**	−11.154*	−11.380*	−3.936*	−13.300*	−11.880*
IPS	−15.469*	−9.862*	−6.751*	−10.187*	−8.813*	−5.534*	−13.069*	−13.658*	−7.859*	−12.305*	−10.636*
Fisher-ADF	232.525*	145.123*	113.103*	143.824*	120.455*	89.756*	187.553*	201.237*	119.532*	177.263*	149.814*
Fisher-PP	375.747*	249.696*	221.185*	273.270*	258.223*	137.480*	285.779*	320.660*	37.434**	269.599*	267.664*

Note:
* Indicates 1% level of significance.
** Indicates 5% level of significance.

Table 3
Estimates of Cross-Sectional Dependence Tests.

Methods	AID	AIRTF	AIRTPC	CO_2	ENRG	GDPPC	GHG	NATRENT	POPDEN	RAILGT	RAILPCC
LM_{BP}	379.518*	750.735*	1598.516*	1241.971*	1474.369*	1455.364*	1562.824*	413.168*	2217.897*	776.641*	704.654*
LM_P	29.892*	65.286*	146.119*	112.124*	134.282*	132.470*	142.716*	33.101*	205.175*	67.756*	60.893*
LM-Bias corrected	29.755*	65.149*	145.982*	111.986*	134.145*	132.333*	142.579*	32.963*	205.037*	67.619*	60.755*
CD_P	5.337*	20.952*	39.383*	26.879*	33.666*	35.755*	35.692*	11.144*	47.092*	−1.639	−2.596*

Note:
* Indicates 1% level of significance.

equivalent per capita respectively. The per capita income has a minimum value of 327.371 US$ and a maximum value of 25022.800 US$ with an average value of 3836.123 US$. Finally, the average value of people per square km of land area is 221.420.

Table 1, Panel–B shows the estimates of panel correlation matrix and found that there is a positive correlation of air transportation freight (r = 0.736), transportation passengers carried (r = 0.537), energy demand (r = 0.971), per capita income (r = 0.904), GHG emissions (r = 0.210), railways goods transported (r = 0.429), and railways passengers carried (r = 0.353) with the CO_2 emissions, while there is a negative correlation between CO_2 emissions and bilateral aid flows with a correlation coefficient of r = −0.271. The result implies that environmental quality is affected by transportation sector, energy demand, and per capita income, while bilateral aid flows improve the environmental quality in a region. The impact of bilateral aid, air-railways transportation, energy demand, and per capita income on GHG emissions is positive while population density has a negative correlation with the GHG emissions across nations. Finally, the bilateral aid flows increase the natural resources rents, while air transportation, railways transportation, energy demand, per capita income, and population density decreases total natural resources rents in a panel of countries.

Table 2 presented the summary of panel unit root estimates and found the greater variability in the variables' series during the study time period. The following variables including air transport freight, air transport passengers carried, carbon emissions, energy demand, per capita income, GHG emissions, railways goods transported, and railways passengers carried exhibit a non-stationary series at level, while it become stationary series after taking first difference of the variables, therefore, we may conclude that these variables have an order of integration is one i.e., I(1) in all of the four prescribed panel unit root tests.

The rest of the variables although may consider I(1) variables as at least in any one of the panel unit root tests reject the null hypothesis of unit root process at level, however, the bilateral aid flows exhibit level stationary as per the estimates of Fisher–PP unit root test, natural resources rents are level stationary as per the estimates of IPS and Fisher–PP unit root tests, and population density is I(0) variable as per the estimates of LLC, Fisher–ADF and Fisher–PP unit root tests. However, bilateral aid flow exhibit differenced stationary as per the unit root estimates of LLC, IPS, and Fisher–ADF tests. The natural resources rents confirmed I(1) variable as per the unit root estimates of LLC and Fisher–ADF tests, similarly, population density is differenced stationary as per the unit root estimates of IPS test. Thus, we may conclude that the given variables rejected the null hypothesis of either common unit root process and/or individual unit root process at least in one of the prescribed panel unit root tests, which generally in favor of I(1) variables series. Fig. 2 shows the differenced data plots for the ready reference.

Table 3 presented the estimates of cross-sectional dependence tests by Breusch-Pagan LM test, Pesaran scaled LM test, bias corrected LM test, and Pesaran CD test. The significant statistics values for all the selected variables except railways goods transported, the results safely rejected the null hypothesis of no cross-sectional dependence in panel units, while the railways goods transported also have a significant statistics values of first three tests, however, as per the insignificant statistics value of Pesaran CD test we may partially consider that the given variable fail to reject the null hypothesis of no correlation in the cross-sectional units.

After the confirmation of I(1) order of integration in majority of the panel unit root tests, it is likely to estimate the panel cointegration test. Table 4 shows the estimates of Johansen Fisher panel cointegration test for all three models separately and found

Table 4
Johansen Fisher panel cointegration test.

Model-1: CO_2 AID AIRTF AIRTPC ENRG GDPPC POPDEN RAILGT RAILPC				
Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Hypothesized	Fisher Stat.*		Fisher Stat.*	
No. of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	384.4	0.0000	495.4	0.0000
At most 1	605.8	0.0000	198.3	0.0000
At most 2	364.9	0.0000	170.7	0.0000
At most 3	232.9	0.0000	104.5	0.0000
At most 4	142.5	0.0000	82.46	0.0000
At most 5	76.03	0.0000	40.64	0.0091
At most 6	49.95	0.0006	35.17	0.0372
At most 7	32.10	0.0757	27.74	0.1845
At most 8	30.49	0.1069	30.49	0.1069
Model-11: GHG AID AIRTF AIRTPC ENRG GDPPC POPDEN RAILGT RAILPC				
Hypothesized	Fisher Stat.*		Fisher Stat.*	
No. of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	358.0	0.0000	575.5	0.0000
At most 1	599.0	0.0000	243.1	0.0000
At most 2	329.7	0.0000	135.2	0.0000
At most 3	213.9	0.0000	93.22	0.0000
At most 4	132.6	0.0000	64.11	0.0000
At most 5	80.29	0.0000	38.59	0.0157
At most 6	55.76	0.0001	36.77	0.0251
At most 7	36.57	0.0264	32.02	0.0770
At most 8	31.69	0.0828	31.69	0.0828
Model-111: NATRENT AID AIRTF AIRTPC ENRG GDPPC POPDEN RAILGT RAILPC				
Hypothesized	Fisher Stat.*		Fisher Stat.*	
No. of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	374.8	0.0000	484.8	0.0000
At most 1	568.0	0.0000	205.2	0.0000
At most 2	336.0	0.0000	135.2	0.0000
At most 3	220.4	0.0000	86.44	0.0000
At most 4	143.7	0.0000	69.30	0.0000
At most 5	85.71	0.0000	43.09	0.0046
At most 6	57.50	0.0001	40.21	0.0102
At most 7	36.13	0.0294	33.46	0.0557
At most 8	27.69	0.1862	27.69	0.1862

Note:
* Indicates probabilities are computed using asymptotic Chi-square distribution.

seven cointegration equations by trace test and maximum-Eigen test for model-1.

Similarly for the model-11, the trace statistics and maximum-Eigen statistics both confirmed the eight cointegration equations, while for the model-111, both the statistics confirmed the seven cointegration equations. The number of cointegration equations in all three prescribed models rejects the null hypothesis of 'no cointegration' and conclude that there is a long-run equilibrium relationships between the variables during the study time period. The study further estimate the panel FMOLS for carbon emissions and presented the results in Table 5.

The results of panel FMOLS confirmed the inverted U-shaped relationship between carbon emissions and (i) air transport passengers carried, (ii) railways passengers carried, and (iii) per capita income, which confirmed the transportation induced EKC curve and carbon EKC curve for the region. The result implies that air transportation considerably increases carbon emissions with estimated elasticities of 0.047% in Eq. (1) and 0.046% in Eq. (4) while it decreases after reaching the certain threshold level. There is a positive and significant impact of railways goods transported on carbon emissions with an estimated elasticity of 0.047% in Eqs. (1) and (4) and 0.055% in Eq. (2). The results imply that higher the transportation of railways goods, higher will be the carbon emissions, which further indicate the positive relationship between railways passengers carried and carbon emissions and found the non-linear relationship in the form of inverted U-shaped relationships between them. The railways passenger goods increases carbon emissions which decline the environmental quality, while after reaching the certain threshold, this relationship is averted and improve the

Table 5
Estimates of panel FMOLS for CO_2 emissions.

Variables	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)
ln(AIRTF)	0.003	0.0008	0.014	−0.003
ln(AIRTPC)	0.047**	0.030	0.034	0.046**
AIRTPC^2	−2.98E−17**	–	–	–
ln(RAILGT)	0.047**	0.055**	0.0005	0.047**
ln(RAILPC)	0.095*	0.117*	0.062*	0.097*
RAILPC^2	–	−1.99E−10*	–	–
ln(ENRG)	0.181	0.196***	0.502*	0.184
ln(GDPPC)	0.637*	0.622*	0.656*	0.606*
GDPPC^2	–	–	−1.23E−09*	–
ln(AID)	−0.019	−0.024***	−0.010	−0.021
AID^2	–	–	–	1.89E−21
ln(POPDEN)	0.337*	0.466*	0.005	0.357*
Statistical Tests				
R-squared	0.979	0.980	0.981	0.979
Adjusted R-squared	0.978	0.979	0.980	0.978
Long-run variance	0.058	0.056	0.056	0.058

Note:
* Indicates 1% level of significance.
** Indicates 5% level of significance.
*** Indicates 10% level of significance.

Table 6
Estimates of FMOLS for GHG emissions.

Variables	Eq. (5)	Eq. (6)	Eq. (7)	Eq. (8)
ln(AIRTF)	0.045**	0.027	0.028	0.028
ln(AIRTPC)	0.030	0.031	0.020	0.020
AIRTPC^2	−6.60E−17*	–	–	–
ln(RAILGT)	−0.103*	−0.112*	−0.103*	−0.104*
ln(RAILPC)	−0.030	−0.044***	−0.025	−0.026
RAILPC^2	–	1.76E−10**	–	–
ln(ENRG)	0.812*	0.813*	0.814*	0.814*
ln(GDPPC)	−0.022	−0.095	−0.088	−0.087
GDPPC^2	–	–	3.91E−11	–
ln(AID)	0.050*	0.062*	0.055*	0.054
AID^2	–	–	–	4.51E−22
ln(POPDEN)	0.346*	0.274**	0.386**	0.387*
Statistical Tests				
R-squared	0.934	0.928	0.927	0.927
Adjusted R-squared	0.931	0.924	0.924	0.924
Long-run Variance	0.069	0.079	0.081	0.081

Note:
* Indicates 1% level of significance.
** Indicates 5% level of significance.
*** Indicates 10% level of significance.

environmental quality to decrease carbon emissions. The impact of energy demand on carbon emissions is positive, which indicates in Eq. (2) and Eq. (3) with an estimated elasticities of 0.196, $p < 0.090$ and 0.502, $p < 0.000$ respectively. The bilateral aid flow decreases carbon emissions in Eq. (2), however, it does not translate into an inverted U-shaped relationship, as both the aid and its square term insignificant to explain their impact on carbon emissions, which shows flat/no relationship between them. Finally, the impact of population density on carbon emissions is clearly evident in Eqs. (1), (2), and (4) with an estimated elasticities of 0.337%, $p < 0.000$; 0.466%, $p < 0.000$; and 0.357%, $p < 0.000$ respectively. The results are consistent with the previous studies of He et al. (2013), Li et al. (2013), Konur and Schaefer (2014), Egilmez and Park (2014), Zhang and Wei (2015), Zhang et al. (2015), Fan and Lei (2016), etc. Carbon mitigating strategies is desirable for global sustainability agenda that may achieve through proper urban development policies mediated with the urban passenger transportation sector, which should be sustained through public transportation and limited usage of cars, which will substantially reduced transport energy demand (He et al., 2013). It is evident that carbon mitigating strategies chiefly compromised by unsustainable economic growth, which considerably increases road freight transportation induced CO_2 emissions that highly risk to the global sustainability agenda (Li et al., 2013). Sustainable transportation planning would helpful to regulate low carbon policies (Konur and Schaefer, 2014) while food manufacturing sector should be concentric with the low carbon intensity, energy and water footprints of transportation sector for eco-efficiency balance at

Table 7
Estimates of FMOLS for total natural resources rents.

Variables	Eq. (9)	Eq. (10)	Eq. (11)	Eq. (12)
ln(AIRTF)	−0.229*	−0.237*	−0.213*	−0.242*
ln(AIRTPC)	0.315*	0.306*	0.292*	0.307*
AIRTPC^2	−4.33E−17	–	–	–
ln(RAILGT)	0.151**	0.146***	0.078	0.150**
ln(RAILPC)	0.094	0.096	0.044	0.097
RAILPC^2	–	8.91E−13	–	–
ln(ENRG)	−0.663	−0.631	−0.127	−0.681***
ln(GDPPC)	−0.423	−0.477	−0.427	−0.449
GDPPC^2	–	–	−1.34E−09	–
ln(AID)	0.104**	0.106**	0.112*	0.110**
AID^2	–	–	–	−1.75E−21
ln(POPDEN)	0.391	0.404	−0.112	0.431
Statistical Tests				
R-squared	0.890	0.889	0.891	0.889
Adjusted R-squared	0.885	0.884	0.885	0.883
Long-run variance	0.673	0.666	0.655	0.672

Note:
* Indicates 1% level of significance.
** Indicates 5% level of significance.
*** Indicates 10% level of significance.

Table 8
Estimates of Dumitrescu Hurlin panel causality tests.

Variables	AID	AIRTF	AIRTPC	CO_2	ENRG	GDPPC	GHG	NATRENT	POPDEN	RAILGT	RAILPC
AID	N/A	≠	≠	≠	≠	≠	≠	≠	→	≠	≠
AIRTF	→	N/A	≠	≠	→	≠	≠	≠	→	→	→
AIRTPC	→	→	N/A	≠	≠	≠	≠	≠	≠	≠	→
CO_2	→	≠	→	N/A	≠	↔	≠	→	≠	≠	≠
ENRG	→	≠	≠	≠	N/A	→	≠	↔	≠	→	≠
GDPPC	≠	≠	≠	↔	≠	N/A	↔	→	↔	↔	↔
GHG	≠	≠	→	≠	≠	↔	N/A	≠	↔	↔	→
NATRENT	→	→	≠	≠	↔	≠	≠	N/A	→	≠	→
POPDEN	≠	≠	→	≠	≠	↔	↔	≠	N/A	≠	≠
RAILGT	→	≠	≠	≠	≠	↔	↔	≠	≠	N/A	≠
RAILPC	≠	≠	≠	≠	≠	↔	≠	≠	→	≠	N/A

Note: The significant W-stat and Zbar-statistics rejected the null hypothesis of no causality between the two variables. → shows one-way linkage, ↔ shows two way linkages, and ≠ no causality between the variables. N/A means not applicable.

nationwide (Egilmez and Park, 2014). The prolific growth of carbon emissions is driven by transported related technological innovations, which is not been stemmed with environmental sustainability instruments (Zhang and Wei, 2015) while it is desirable to innovate with the sustainable technological instruments that would substantially improve the performance of global air quality indicators (Zhang et al., 2015). The development of low carbon intensified vehicles, restricting private vehicles and promotion of public transportation all are the desired way to achieve sustainability agenda across nations (Fan and Lei, 2016).

Table 6 shows the estimates of panel FMOLS for GHG emissions and found that air transport freight substantially increases GHG emissions i.e., if there is 1% increase in air transportation freight, GHG emission increases by 0.045%, which implies that air freight have a greater variance in order to increase GHG emissions across nations. The results confirmed the non-linear decreasing relationship between air transportation passengers carried and GHG emissions, which indicate that after certain threshold level when air transportation passenger carried it decline the GHG emissions by effective government policies for sustainable development in a region. The railways goods transported decreases GHG emissions, followed by a U-shaped relationship between railways passengers carried and GHG emissions, which implies that railways passengers carried first improves the environmental quality in order to decrease GHG emissions, while at the later stages of development, higher railways passengers carried deteriorate the environmental quality in order to increase GHG emissions across countries.

The impact of energy demand on GHG emissions is positive in all four equations i.e., from Eqs. (5)–(8), which implies that higher energy demand deteriorates the environmental quality in a way to increase GHG emissions. The result does not find any significant association between per capita income and GHG emissions, and further confirmed the flat relationship between them. The results find the positive relationship between bilateral aid flow and GHG emissions from Eqs. (5)–(7), while it further confirmed the flat relationship between aid and GHG emissions in Eq. (8). Population density found a sound predictor to influence environment in a way to increase GHG emissions that required strong policies to mitigate climate change impact across countries. The results are in line with the previous studies of Greene (2006), Woodcock et al. (2009), Cristea et al. (2013), Pongthanaisawan and Sorapipatana (2013),

Table 9
Estimates of variance decomposition analysis for CO_2 emissions, GHG emissions, and total natural resources rents.

Variance Decomposition of Δln(CO_2)

Period	S.E.	Δln(CO_2)	Δln (AID)	Δln (AIRTF)	Δln (AIRTPC)	Δln (ENRG)	Δln (GDPPC)	Δln (POPDEN)	Δln (RAILGT)	Δln (RAILPC)
2016	0.086942	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2017	0.090202	92.94644	0.435670	0.011078	4.041727	1.317420	0.003299	0.033296	1.164640	0.046432
2018	0.092579	88.35722	0.432567	0.164604	3.922629	1.984402	0.658271	0.031609	2.677774	1.770921
2019	0.093012	87.64614	0.434020	0.182851	3.892414	2.216378	0.754715	0.060922	3.013370	1.799188
2020	0.093136	87.49668	0.498458	0.184175	3.895360	2.245433	0.778693	0.089871	3.005934	1.805395
2021	0.093187	87.40697	0.499425	0.183972	3.899715	2.261502	0.777901	0.108906	3.015264	1.846349
2022	0.093203	87.37959	0.499707	0.183911	3.898368	2.263126	0.778004	0.121383	3.022750	1.853164
2023	0.093217	87.36259	0.500229	0.183990	3.897281	2.263059	0.778054	0.135016	3.025179	1.854599
2024	0.093223	87.35212	0.500212	0.183987	3.896796	2.263414	0.777957	0.146157	3.024812	1.854544
2025	0.093228	87.34168	0.500251	0.183979	3.896390	2.263721	0.778599	0.155598	3.024487	1.855300

Variance Decomposition of Δln(GHG)

Period	S.E.	Δln (GHG)	Δln (AID)	Δln (AIRTF)	Δln (AIRTPC)	Δln (ENRG)	Δln (GDPPC)	Δln (POPDEN)	Δln (RAILGT)	Δln (RAILPC)
2016	0.159348	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2017	0.176461	95.23671	0.174606	0.121063	0.954454	2.503920	0.945102	0.005096	0.043917	0.015132
2018	0.181364	94.18677	0.302499	0.116682	1.051916	2.863752	1.090516	0.198362	0.165389	0.024109
2019	0.185585	94.03398	0.382973	0.166428	1.006914	2.892455	1.125767	0.194907	0.157979	0.038599
2020	0.185743	93.87493	0.392326	0.177161	1.039626	2.910423	1.124134	0.195699	0.169308	0.116392
2021	0.186348	93.84105	0.390688	0.178767	1.032982	2.934750	1.122729	0.209543	0.169862	0.119630
2022	0.186462	93.80323	0.398452	0.182384	1.035349	2.937400	1.129832	0.213614	0.173459	0.126279
2023	0.186499	93.79775	0.398431	0.182374	1.035683	2.937457	1.130374	0.215075	0.173934	0.128925
2024	0.186533	93.79023	0.398998	0.182793	1.035553	2.938117	1.130462	0.219908	0.174267	0.129668
2025	0.186538	93.78536	0.399362	0.182847	1.035630	2.938052	1.130712	0.223516	0.174370	0.130152

Variance Decomposition of Δln (NATRENT):

Period	S.E.	Δln (NATRENT)	Δln (AID)	Δln (AIRTF)	Δln (AIRTPC)	Δln (ENRG)	Δln (GDPPC)	Δln (POPDEN)	Δln (RAILGT)	Δln (RAILPC)
2016	0.288016	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2017	0.294248	95.81205	3.429693	0.114099	0.114501	0.076052	0.053995	0.124874	0.134385	0.140347
2018	0.295916	95.19007	3.463214	0.113811	0.268452	0.078929	0.293205	0.158544	0.279911	0.153859
2019	0.296291	94.95423	3.630699	0.127386	0.271807	0.079108	0.324173	0.162657	0.282961	0.166978
2020	0.296379	94.89803	3.628724	0.133201	0.273366	0.081819	0.325320	0.174765	0.293037	0.191735
2021	0.296398	94.88592	3.630783	0.133185	0.273622	0.082852	0.325846	0.179915	0.293786	0.194088
2022	0.296421	94.87243	3.630294	0.133651	0.273681	0.082908	0.326325	0.187167	0.293826	0.199718
2023	0.296432	94.86610	3.630213	0.133653	0.273682	0.083099	0.326386	0.193030	0.294022	0.199817
2024	0.296441	94.86055	3.629992	0.133647	0.273690	0.083215	0.326376	0.198207	0.294168	0.200158
2025	0.296448	94.85615	3.629831	0.133655	0.273684	0.083267	0.326439	0.202594	0.294180	0.200196

Sim et al. (2015), Zeng et al. (2016), etc. The renewable energy sources would helpful to reduce GHG emissions, while biomass fuels are the promising solution to mitigate GHG emissions from transport sector. In addition, the regional development and proper transportation planning further helpful to reduce global GHG emissions (Greene, 2006). For public health safety concerns, climate change mitigation policies in transport are prerequisite for healthy and wealthy travels (Woodcock et al., 2009). It is evident that more than 30% of international transportation is responsible for global trade emissions, while flexibility of trade tariffs lead to transport emissions that required more concentrated efforts to reduce global trade emissions (Cristea et al., 2013). The short- and long-term GHG mitigation efforts required fuel-switching and energy optimization options for sustainability in transportation sector (Pongthanaisawan and Sorapipatana, 2013), while it is further need to carbon adjusted policies in road transportation for meeting the desired emissions reduction (Zeng et al., 2016) to improve the national environment by eco-friendly manners (Sim et al., 2015).

Table 7 shows the estimates of panel FMOLS for total natural resources rents and found that air transport freight decreases the natural resources rents while air transport of passenger carried substantially increase natural resources rents, however, it is not further translated in to inverted U-shaped relationship, as the square term of air transport passenger carried is insignificant to explain its impact on natural resources rents, which shows the monotonic increasing relationship between them.

The railways goods transported have a positive relationship with the natural resource rents, while railways passengers carried is insignificant to explain its impact on natural resource rents, which further shows the flat relationship between them. The impact of energy demand on natural resource rents is negative, which implies that higher energy demand decreases the natural resource rents in a region. The results does not supported the inverted U-shaped relationship between GDP per capita and CO2 emissions, as it has no significant association of income and its square term on natural resource rents. The impact of bilateral aid on natural resource rents is positive in all four equations from Eqs. (9)–(12), however, the square term of bilateral aid flow is insignificant to explain its impact on natural resource rents, which confirmed the monotonic increasing relationship between aid and natural resource rent. The result does not find any traces of population density to degrade natural resources in a panel of countries. The results supported the

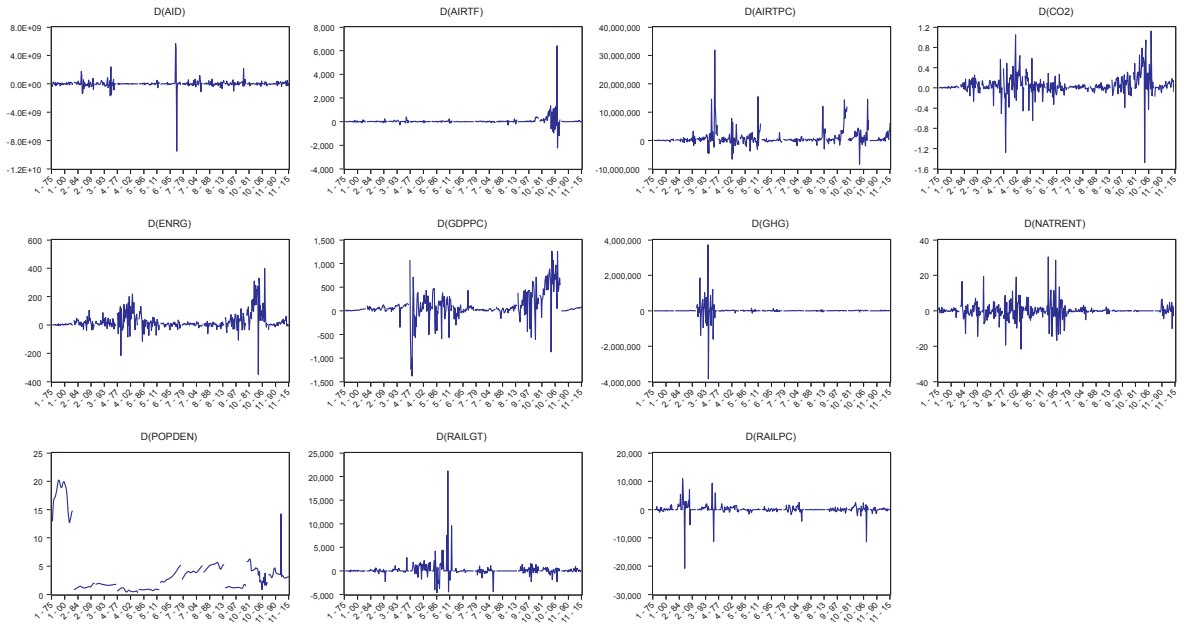


Fig. 2. Plots of differenced data.
Source: World Bank (2015).

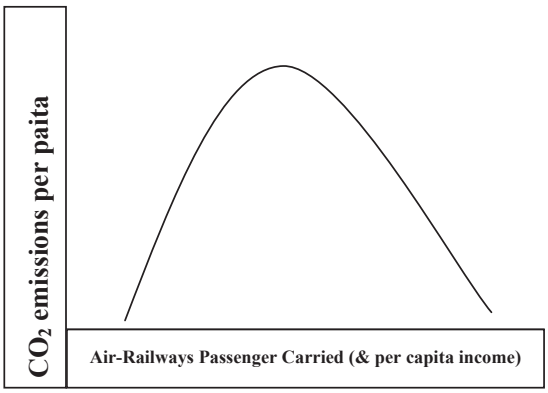
following studies i.e., Månsson (2015), Lin and Ahmad (2016), Mustapa and Bekhet (2016), Deendarlianto et al. (2017), etc. The capital investment in the transportation sector would helpful to promote energy saving and cleaner production technologies that translated into the reduction in carbon emissions. The capital substitution effect in the energy and transportation upgrade the natural environment with less carbonized material in the atmosphere (Lin and Ahmad, 2016). Although, renewable energy sources considered one of the potential contributing factor that minimize the environmental threats that previously emerged with the usage of conventional fossil fuel energy, however, renewable energy system also have some limitations and conflict with time and space to control in sustainable manners (Månsson, 2015). There are number of viable solutions to mitigate carbon emission from transportation sector, i.e., removal of fuel price subsidy (Mustapa and Bekhet, 2016) promote CNG vehicles on public transportation and retreat old vehicles (Deendarlianto et al., 2017). These mitigating options are desirable for conserve natural environment across countries. Fig. 3 shows the summary of EKC hypothesis for ready reference.

Table 8 shows the panel causality estimates and confirmed the bidirectional causality between (i) CO_2 emissions and per capita income, (ii) energy demand and natural resource rents, (iii) GHG emissions and per capita income, (iv) population density and per capita income, (v) railways goods transported and per capita income, (vi) railways passengers carried and per capita income, (vii) GHG emissions and population density, and (viii) GHG emissions and railways goods transported.

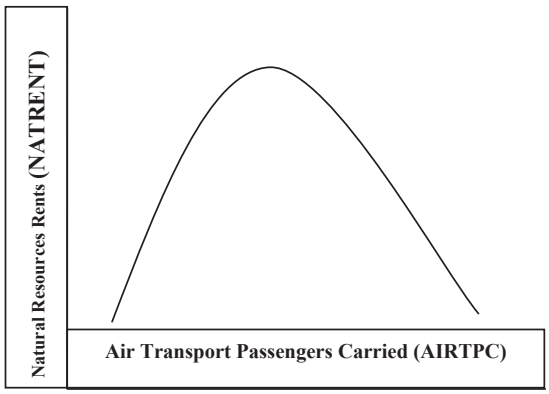
The causality results further confirmed the unidirectional relationship running from (i) bilateral aid flow and population density, (ii) air transport freight and bilateral aid, (iii) air transport freight and energy demand, (iv) air transport freight and population density, (v) air transport passengers carried and bilateral aid, (vi) CO_2 emissions and bilateral aid, (vii) CO_2 emissions and air transport passengers carried, (viii) energy demand and bilateral aid, (ix) energy demand and per capita income, (x) energy demand and railways goods transported, (xi) per capita income and natural resource rents, (xii) GHG emissions and air transportation passengers carried, (xiii) GHG emissions and railways passengers carried, (xiv) natural resource rents and bilateral aid, (xv) natural resource rents and air transport freight, (xvi) natural resource rents and population density, (xvii) natural resource rents and railways passengers carried, (xviii) population density and air transport passengers carried, (xix) railways goods transported and bilateral aid, and (xx) railways passengers carried and population density. The remaining variables hold the neutrality hypothesis, which does not have any cause effect relationship with each other, although highly correlated in panel FMOLS regression estimator.

Table 9 shows the panel variance decomposition analysis and found that air transport passengers carried will largely influence CO_2 emissions for the next ten years period i.e., from 2016 to 2025, followed by railways goods transported, energy demand, railways passengers carried, per capita income, bilateral aid, and air transport freight. The population density will be the least influence on carbon emissions for the next ten years time period.

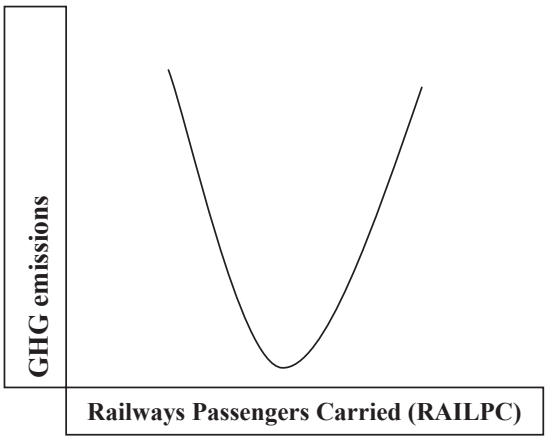
Table 9 further shows that energy demand will largely influence the GHG emissions while the railways passengers carried will least influence GHG emissions for the next ten years period. Finally, the natural resource rents will majorly influenced by bilateral aid flow, while it least influence by energy demand for next coming decades. The estimates confirmed the various factors that have a considerable proportion to affect carbon emissions, GHG emissions, and natural resource rents, while the sound policy is required to mitigate climate change through sustainable policy instruments for broad based growth in a region.



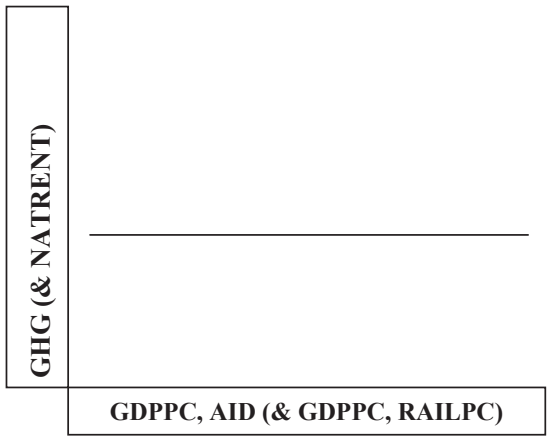
a) Inverted U-shaped relationship between CO_2 and AIRTPC-RAILPC & GDPPC



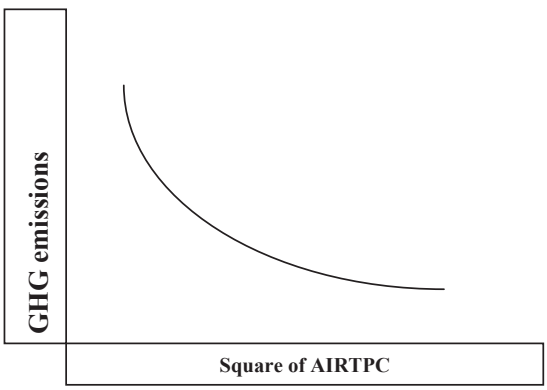
b) Inverted U-shaped relationship between NATRENT and AIRTPC



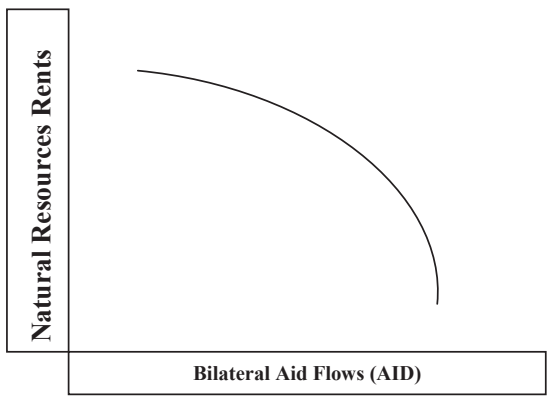
c) U-shaped relationship between GHG and RAILPC



d) Flat relationship between GHG and GDPPC (&AID), and NATRENT and GDPPC (& RAILPC)



e) Negative non-linear relationship between GHG emissions and square of AIRTPC



f) Monotonic increasing relationship between NATRENT and AID

Fig. 3. Summary of EKC hypothesis with air-railways transportation, per capita income, and bilateral aid flows.

4. Conclusions

The objective of the study is to examine the impact of air transportation, railways transportation, energy demand, bilateral aid flows, and population density on carbon dioxide (CO2) emissions, greenhouse gas (GHG) emissions, and natural resource rents in a panel of Next-11 countries, for the period of 1975–2015. The study employed panel heterogeneous cointegration techniques including panel unit root tests, cross-sectional dependence tests, panel cointegration, panel FMOLS estimator, panel causality estimates,

and panel variance decomposition analysis. The panel unit root tests rejected the common and individual unit root process and found differenced stationary variables' series in majority of the cases. The cross-sectional dependence tests rejected the absence of cross-sectional dependence from the panel units and confirmed the correlation in the cross-sectional units. The panel cointegration tests rejected the 'no cointegration' hypothesis against the alternative ones. The results of panel Fully Modified OLS (FMOLS) confirmed the inverted U-shaped relationship between (i) air transportation passengers carried and CO_2 emissions, (ii) railways passengers carried and CO_2 emissions, and (iii) per capita income and CO_2 emissions. The U-shaped relationship is found between railways passengers carried and GHG emissions, while non-linear and decreasing relationship is found between square of air transport passengers carried and GHG emissions. The results further confirmed the upward sloping EKC curve for (i) air transport passengers carried and natural resource rents and (ii) bilateral aid flow and natural resource rents. There is no/flat relationship between (i) per capita GDP and GHG emissions, (ii) bilateral aid flow and GHG emissions, (iii) railways passengers carried and natural resource rents, and (iv) bilateral aid flow and natural resource rents. The air transport freight has a positive relationship with the GHG emissions and negative relationship with the natural resource rents, while railways goods transported have a positive relationship with the CO_2 emissions and natural resource rents while it has a negative relationship with the GHG emissions. Energy demand and population density both escalates CO_2 emissions and GHG emissions, while energy demand has a negative relationship with the natural resource rents and population density does not explain its significant impact on natural resource rents. The key causality estimates confirmed the feedback relationship of CO_2 emissions, GHG emissions, population density, railways goods transported and railways passengers carried with the per capita income, while the result further substantiate the following causality directions i.e., energy led aid and growth, growth led natural resources, natural resource led aid, population led air transportation, and railways led aid hypothesis in a region. The estimates of panel variance decomposition analysis shows that CO_2 emissions, GHG emissions, and natural resource rents will largely influence by air transportation passengers carried, energy demand, and bilateral aid flow, while it will least influence by population density, railways passengers carried, and energy demand respectively, for the next ten year period.

On the basis of significant discussions, we proposed the following policy implications for the Next-11 countries i.e.,

(i) The impact of air and railways transportation on carbon emissions is positive, therefore, it is imperative to design the transportation sector more sustainable by using low-carbon intensified vehicles and promote green instruments through approved government legislative bodies for initiating 'go with green' vehicle policy.
(ii) The air transport freight increases GHG emissions, which is making so hard to implement green vehicle policies for sustainability in a region. It is desirable to mitigate climate change by rigid freight charges and give focused on other modes of transport that should be less sensitive to the GHG emissions.
(iii) The impact of energy demand on carbon emissions and GHG emissions is positive, which implies that higher energy demand deteriorates the country's environment, although it is imperative for economic development and broad-based growth for Next-11 countries, however, the quest for renewable energy sources should be the key policy agenda for the countries to provoke the sustainability agenda.
(iv) The impact of economic growth on carbon emissions is quite visible that affects the global sustainability agenda, while its impact is inverted after reaching the certain growth threshold to reduce carbon emissions in Next-11 countries. The economic policies should be contractionary and rigid while devising environmental sustainability policies, as it should not be compromised by trade gains to allow dirty polluting industries in a country that deteriorates the global environment.
(v) The bilateral aid flows more prone to increase climatic variability by increasing GHG emissions in a panel of Next-11 countries. The aid should be spend on developmental projects by keeping in view to protect the natural environment through allocated a significant proportion of aid share to mitigate climate change in a region.
(vi) Population density is the key predictor that largely influence carbon emissions and GHG emissions, so it is necessary to designed land reforms policies to reduce the population pressure from arable land and allocated the significant proportion of arable land for agricultural production that would helpful to improve environmental quality in a region.
(vii) Transportation sector is highly influenced to the natural resource rents, as air transport passengers carried and railways goods transported both increases natural resource rents, while air transport freight and energy demand considerably decreases the share of natural resource rents in a region. The policy should be made to sustain the natural resource rents as it is further linked with the bilateral aid flows, which required resource conservation policies to balanced eco-environment of sustainability across countries.

The environmental impacts of transportation are largely attributed with the high risks of climate change and produced massive carbon emissions, which lead to the global warming. The aviation emissions, road transportation, and shipping are associated with the length of flight, commute with rail and subway trains, and discharge of sewage into water largely influenced environment and air quality to pollute global environment. The sustainable transportation planning is the desirable solution for healthy and wealthy travelling across nations.

Acknowledgement

Funding recipient: Elsayed Elsherbini Elashkar and Alaa Mohamd Shoukry. The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through research group no. RG-1439-015.

References

Abdallah, K.B., Belloumi, M., De Wolf, D., 2013. Indicators for sustainable energy development: a multivariate cointegration and causality analysis from Tunisian road transport sector. Renew. Sustain. Energy Rev. 25, 34–43.

Almeida, A.N., Santos, A.S., Halmenschlager, V., Gilio, L., Diniz, T.B., Ferreira, A. A., 2016. Flexible-fuel automobiles and CO2 emissions in Brazil: a semiparametric analysis using panel data. In: 2016 Annual Meeting, July 31–August 2, 2016, Boston, Massachusetts (No. 235733). Agricultural and Applied Economics Association (May).

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., Mohammed, A.H., 2015. Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. Ecol. Ind. 48, 315–323.

Chandran, V.G.R., Tang, C.F., 2013. The impacts of transport energy consumption, foreign direct investment and income on CO_2 emissions in ASEAN-5 economies. Renew. Sustain. Energy Rev. 24, 445–453.

Cristea, A., Hummels, D., Puzzello, L., Avetisyan, M., 2013. Trade and the greenhouse gas emissions from international freight transport. J. Environ. Econ. Manage. 65 (1), 153–173.

Deendarlianto, Widyaparaga, A., Sopha, B.M., Budiman, A., Muthohar, I., Setiawan, I.C., Lindasista, A., Soemardjito, J., Oka, K., 2017. Scenarios analysis of energy mix for road transportation sector in Indonesia. Renew. Sustain. Energy Rev. 70, 13–23.

Dogan, E., Aslan, A., 2017. Exploring the relationship among CO_2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: evidence from panel models robust to heterogeneity and cross-sectional dependence. Renew. Sustain. Energy Rev. 77, 239–245.

Dogan, E., Seker, F., Bulbul, S., 2017. Investigating the impacts of energy consumption, real GDP, tourism and trade on CO_2 emissions by accounting for cross-sectional dependence: a panel study of OECD countries. Curr. Issues Tourism 20 (16), 1701–1719.

Dumitrescu, E.I., Hurlin, C., 2012. Testing for Granger non-causality in heterogeneous panels. Econ. Model. 29 (4), 1450–1460.

Eghbal, M., 2008. The Next 11 emerging economies. Euromonitor International. Online available at: < http://blog.euromonitor.com/2008/02/the-next-11-emerging-economies.html > (accessed on 5th December, 2016).

Egilmez, G., Park, Y.S., 2014. Transportation related carbon, energy and water footprint analysis of US manufacturing: an eco-efficiency assessment. Transp. Res. Part D: Transp. Environ. 32, 143–159.

Fan, F., Lei, Y., 2016. Decomposition analysis of energy-related carbon emissions from the transportation sector in Beijing. Transp. Res. Part D: Transp. Environ. 42, 135–145.

Geng, Y., Ma, Z., Xue, B., Ren, W., Liu, Z., Fujita, T., 2013. Co-benefit evaluation for urban public transportation sector–a case of Shenyang, China. J. Clean. Prod. 58, 82–91.

Greene, D.L., 2006. Reducing greenhouse gas emissions from transportation. legislative commission on global climate change. In: 25th April, 2006, North Carolina. Online available at: < http://www.ncga.state.nc.us/documentsites/committees/LCGCC/Meeting%20Documents/2005-2006%20Interim/25%20April%202006/Presentations/LCGCC-%20Greene.pdf > (accessed on 4th December, 2016).

He, D., Liu, H., He, K., Meng, F., Jiang, Y., Wang, M., Zhou, J., Calthorpe, P., Guo, J., Yao, Z., Wang, Q., 2013. Energy use of, and CO_2 emissions from China's urban passenger transportation sector–carbon mitigation scenarios upon the transportation mode choices. Transp. Res. Part A: Policy Pract. 53, 53–67.

He, K., Huo, H., Zhang, Q., He, D., An, F., Wang, M., Walsh, M.P., 2005. Oil consumption and CO_2 emissions in China's road transport: current status, future trends, and policy implications. Energy Policy 33 (12), 1499–1507.

IEA, 2009. Transport, Energy, and CO2: Moving Toward Sustainability. International Energy Agency, Paris, France. Online available at: < https://www.iea.org/publications/freepublications/publication/transport2009.pdf > (accessed on 5th December, 2016).

Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. J. Econometrics 115 (1), 53–74.

IPCC, 2014. Climate Change: Implications for Transport. Key Findings from the Intergovernmental Panel on Climate Change Fifth Assessment Report. Cambridge University Press, USA. Online available at: < https://www.bsr.org/reports/BSR-Cambridge-Climate-Change-Implications-for-Transport.pdf > (accessed on 5th December, 2016).

Jebli, M.B., 2016. On the causal links between health indicator, output, combustible renewables and waste consumption, rail transport, and CO_2 emissions: the case of Tunisia. Environ. Sci. Pollut. Res. 23 (16), 16699–16715.

Kamakate, F., Schipper, L., 2009. Trends in truck freight energy use and carbon emissions in selected OECD countries from 1973 to 2005. Energy Policy 37 (10), 3743–3751.

Khan, S.A.R., Qianli, D., SongBo, W., Zaman, K., Zhang, Y., 2017a. Environmental logistics performance indicators affecting per capita income and sectoral growth: evidence from a panel of selected global ranked logistics countries. Environ. Sci. Pollut. Res. 24 (2), 1518–1531.

Khan, S.A.R., Qianli, D., SongBo, W., Zaman, K., Zhang, Y., 2017b. Travel and tourism competitiveness index: the impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. J. Air Transp. Manage. 58, 125–134.

Kim, N.S., Van Wee, B., 2014. Toward a better methodology for assessing CO_2 emissions for intermodal and truck-only freight systems: a European case study. Int. J. Sustain. Transp. 8 (3), 177–201.

Konur, D., 2014. Carbon constrained integrated inventory control and truckload transportation with heterogeneous freight trucks. Int. J. Prod. Econ. 153, 268–279.

Konur, D., Schaefer, B., 2014. Integrated inventory control and transportation decisions under carbon emissions regulations: LTL vs. TL carriers. Transp. Res. Part E: Logistics Transp. Rev. 68, 14–38.

Lai, K.H., Wong, C.W., 2012. Green logistics management and performance: some empirical evidence from Chinese manufacturing exporters. Omega 40 (3), 267–282.

Langbroek, J.H., Franklin, J.P., Susilo, Y.O., 2017. Electric vehicle users and their travel patterns in Greater Stockholm. Transp. Res. Part D: Transp. Environ. 52, 98–111.

Levin, A., Lin, C.F., Chu, C.S.J., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. J. Econometrics 108 (1), 1–24.

Li, H., Lu, Y., Zhang, J., Wang, T., 2013. Trends in road freight transportation carbon dioxide emissions and policies in China. Energy Policy 57, 99–106.

Li, J., Lo, K., Zhang, P., Guo, M., 2016. Consumer travel behaviors and transport carbon emissions: a comparative study of commercial centers in Shenyang, China. Energies 9 (10), 765.

Liaquat, A.M., Kalam, M.A., Masjuki, H.H., Jayed, M.H., 2010. Potential emissions reduction in road transport sector using biofuel in developing countries. Atmos. Environ. 44 (32), 3869–3877.

Lin, B., Ahmad, I., 2016. Energy substitution effect on transport sector of Pakistan based on trans-log production function. Renew. Sustain. Energy Rev. 56, 1182–1193.

Lin, T.P., 2010. Carbon dioxide emissions from transport in Taiwan's national parks. Tourism Manage. 31 (2), 285–290.

Liu, Z., Qin, C.X., Zhang, Y.J., 2016. The energy-environment efficiency of road and railway sectors in China: evidence from the provincial level. Ecol. Ind. 69, 559–570.

Loo, B.P., Banister, D., 2016. Decoupling transport from economic growth: extending the debate to include environmental and social externalities. J. Transp. Geogr. 57, 134–144.

López-Martínez, J.M., Jiménez, F., Páez-Ayuso, F.J., Flores-Holgado, M.N., Arenas, A.N., Arenas-Ramirez, B., Aparicio-Izquierdo, F., 2017. Modelling the fuel consumption and pollutant emissions of the urban bus fleet of the city of Madrid. Transp. Res. Part D: Transp. Environ. 52, 112–127.

Lu, I.J., Lin, S.J., Lewis, C., 2007. Decomposition and decoupling effects of carbon dioxide emission from highway transportation in Taiwan, Germany Japan and South Korea. Energy Policy 35 (6), 3226–3235.

Mansfield, T.J., Gibson, J.M., 2017. A novel dynamic microsimulation model to explore competing transportation health risks (No. 17-02610), Washington D.C.

Månsson, A., 2015. A resource curse for renewables? Conflict and cooperation in the renewable energy sector. Energy Res. Social Sci. 10, 1–9.

Mao, X., Yang, S., Liu, Q., Tu, J., Jaccard, M., 2012. Achieving CO_2 emission reduction and the co-benefits of local air pollution abatement in the transportation sector of China. Environ. Sci. Policy 21, 1–13.

McKinnon, A., 2007. CO2 emissions from freight transport: an analysis of UK data. Online available at: < http://www.greenlogistics.org.uk/SiteResources/d82cc048-4b92-4c2a-a014-af1eea7d76d0_CO2%20Emissions%20from%20Freight%20Transport%20-%20An%20Analysis%20of%20UK%20Data.pdf > (accessed on 5th

December, 2016).
Mittal, S., Dai, H., Shukla, P.R., 2016. Low carbon urban transport scenarios for China and India: a comparative assessment. Transp. Res. Part D: Transp. Environ. 44, 266–276.
Morrow, W.R., Gallagher, K.S., Collantes, G., Lee, H., 2010. Analysis of policies to reduce oil consumption and greenhouse-gas emissions from the US transportation sector. Energy Policy 38 (3), 1305–1320.
Mustapa, S.I., Bekhet, H.A., 2016. Analysis of CO_2 emissions reduction in the Malaysian transportation sector: an optimisation approach. Energy Policy 89, 171–183.
Nassani, A.A., Aldakhil, A.M., Abro, M.M.Q., Zaman, K., 2017. Environmental Kuznets curve among BRICS countries: spot lightening finance, transport, energy and growth factors. J. Clean. Prod. 154, 474–487.
Olsson, L.E., Friman, M., Pareigis, J., Edvardsson, B., 2012. Measuring service experience: applying the satisfaction with travel scale in public transport. J. Retailing Consumer Services 19 (4), 413–418.
Ong, H.C., Mahlia, T.M.I., Masjuki, H.H., 2012. A review on energy pattern and policy for transportation sector in Malaysia. Renew. Sustain. Energy Rev. 16 (1), 532–542.
Paramati, S.R., Shahbaz, M., Alam, M.S., 2017. Does tourism degrade environmental quality? A comparative study of Eastern and Western European Union. Transp. Res. Part D: Transp. Environ. 50, 1–13.
Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J., White, P., 2006. The demand for public transport: the effects of fares, quality of service, income and car ownership. Transp. Policy 13 (4), 295–306.
Pedroni, P., 1996. Fully modified OLS for heterogeneous cointegrated panels and the case of purchasing power parity. Working paper, North American Econometric Society Summer Meeting, pp. 96–120.
Piecyk, M.I., McKinnon, A.C., 2010. Forecasting the carbon footprint of road freight transport in 2020. Int. J. Prod. Econ. 128 (1), 31–42.
Pongthanaisawan, J., Sorapipatana, C., 2013. Greenhouse gas emissions from Thailand's transport sector: trends and mitigation options. Appl. Energy 101, 288–298.
Qureshi, M.I., Hassan, M.A., Hishan, S.S., Rasli, A.M., Zaman, K., 2017. Dynamic linkages between sustainable tourism, energy, health and wealth: evidence from top 80 international tourist destination cities in 37 countries. J. Clean. Prod. 158, 143–155.
Ramachandra, T.V., 2009. Emissions from India's transport sector: statewise synthesis. Atmos. Environ. 43 (34), 5510–5517.
Saboori, B., Sapri, M., bin, Baba, M., 2014. Economic growth, energy consumption and CO_2 emissions in OECD (Organization for Economic Co-operation and Development)'s transport sector: a fully modified bi-directional relationship approach. Energy 66, 150–161.
Shahbaz, M., Mahalik, M.K., Shah, S.H., Sato, J.R., 2016. Time-varying analysis of CO_2 emissions, energy consumption, and economic growth nexus: Statistical experience in next 11 countries. Energy Policy 98, 33–48.
Shahbaz, M., Nasreen, S., Abbas, F., Anis, O., 2015. Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? Energy Econ. 51, 275–287.
Sim, J., 2017. The influence of new carbon emission abatement goals on the truck-freight transportation sector in South Korea. J. Clean. Prod. 164, 153–162.
Sim, S., Oh, J., Jeong, B., 2015. Measuring greenhouse gas emissions for the transportation sector in Korea. Ann. Oper. Res. 230 (1), 129–151.
Talbi, B., 2017. CO_2 emissions reduction in road transport sector in Tunisia. Renew. Sustain. Energy Rev. 69, 232–238.
Thøgersen, J., 2009. Promoting public transport as a subscription service: effects of a free month travel card. Transp. Policy 16 (6), 335–343.
Timilsina, G.R., Shrestha, A., 2009. Transport sector CO_2 emissions growth in Asia: underlying factors and policy options. Energy Policy 37 (11), 4523–4539.
Uusitalo, V., Soukka, R., Horttanainen, M., Niskanen, A., Havukainen, J., 2013. Economics and greenhouse gas balance of biogas use systems in the Finnish transportation sector. Renew. Energy 51, 132–140.
Walmsley, M.R., Walmsley, T.G., Atkins, M.J., Kamp, P.J., Neale, J.R., Chand, A., 2015. Carbon emissions pinch analysis for emissions reductions in the New Zealand transport sector through to 2050. Energy 92, 569–576.
Walnum, H.J., Simonsen, M., 2015. Does driving behavior matter? An analysis of fuel consumption data from heavy-duty trucks. Transp. Res. Part D: Transp. Environ. 36, 107–120.
Wang, Y., Han, R., Kubota, J., 2016. Is there an environmental Kuznets curve for SO_2 emissions? A semi-parametric panel data analysis for China. Renew. Sustain. Energy Rev. 54, 1182–1188.
Wang, Y., Xie, T., Yang, S., 2017. Carbon emission and its decoupling research of transportation in Jiangsu Province. J. Clean. Prod. 142, 907–914.
Waycaster, G.C., Matsumura, T., Bilotkach, V., Haftka, R.T., Kim, N.H., 2017. Review of Regulatory Emphasis on Transportation Safety in the United States, 2002–2009: Public versus Private Modes. Risk analysis (forthcoming issue).
Woodcock, J., Edwards, P., Tonne, C., Armstrong, B.G., Ashiru, O., Banister, D., Beevers, S., Chalabi, Z., Chowdhury, Z., Cohen, A., Franco, O.H., 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. The Lancet 374 (9705), 1930–1943.
World Development Indicators, World Bank, Washington, D.C.
Wu, X., Zhang, S., Wu, Y., Li, Z., Zhou, Y., Fu, L., Hao, J., 2015. Real-world emissions and fuel consumption of diesel buses and trucks in Macao: from on-road measurement to policy implications. Atmos. Environ. 120, 393–403.
Xu, B., Lin, B., 2015. Factors affecting carbon dioxide (CO_2) emissions in China's transport sector: a dynamic nonparametric additive regression model. J. Clean. Prod. 101, 311–322.
Yan, X., Crookes, R.J., 2009. Reduction potentials of energy demand and GHG emissions in China's road transport sector. Energy Policy 37 (2), 658–668.
Zaman, K., Shamsuddin, S., 2017. Green logistics and national scale economic indicators: evidence from a panel of selected European countries. J. Clean. Prod. 143, 51–63.
Zaman, K., Moemen, M.A.E., Islam, T., 2017. Dynamic linkages between tourism transportation expenditures, carbon dioxide emission, energy consumption and growth factors: evidence from the transition economies. Curr. Issues Tourism 20 (16), 1720–1735.
Zeng, Y., Tan, X., Gu, B., Wang, Y., Xu, B., 2016. Greenhouse gas emissions of motor vehicles in Chinese cities and the implication for China's mitigation targets. Appl. Energy 184, 1016–1025.
Zhang, C., Wang, Y., Song, X., Kubota, J., He, Y., Tojo, J., Zhu, X., 2017. An integrated specification for the nexus of water pollution and economic growth in China: panel cointegration, long-run causality and environmental Kuznets curve. Sci. Total Environ. 609, 319–328.
Zhang, N., Wei, X., 2015. Dynamic total factor carbon emissions performance changes in the Chinese transportation industry. Appl. Energy 146, 409–420.
Zhang, N., Zhou, P., Kung, C.C., 2015. Total-factor carbon emission performance of the Chinese transportation industry: a bootstrapped non-radial Malmquist index analysis. Renew. Sustain. Energy Rev. 41, 584–593.
Zhao, Y., Kuang, Y., Huang, N., 2016. Decomposition analysis in decoupling transport output from carbon emissions in Guangdong Province, China. Energies 9 (4), 295.
Zoundi, Z., 2017. CO_2 emissions, renewable energy and the Environmental Kuznets Curve, a panel cointegration approach. Renew. Sustain. Energy Rev. 72, 1067–1075.